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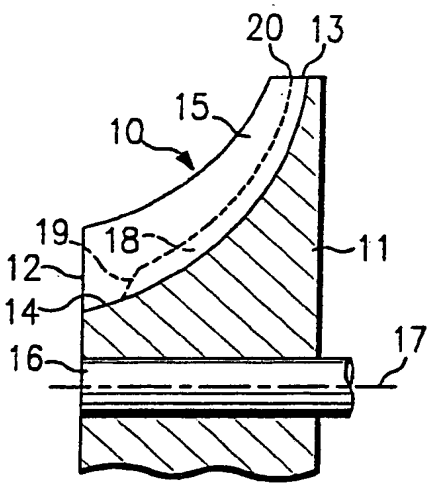
(54) Title: PARTIAL HEIGHT BLADES IN A COMPRESSOR IMPELLER



(57) Abstract

An improved compressor impeller (10) has partial height blades (18) between full height blades (15). The invention is adaptable to radial or mixed flow centrifugal compressors, axial compressors, radial turbines and axial turbines.

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PARTIAL HEIGHT BLADES IN A COMPRESSOR IMPELLER

FIELD OF THE INVENTION

This invention pertains to radial or axial turbomachinery rotors, and more particularly to an impeller having partial height blades between full height blades.

BACKGROUND OF THE INVENTION

The present invention is directed towards improving the flow field within the passages of an axial or centrifugal turbomachine, for example, a centrifugal impeller. Specifically, the invention is intended to reduce the extent of separated flow or wake regions within the impeller and at the same time reduce the blade surface area and the associated frictional effects. Reduced wake at the impeller exit and in the downstream components of flow increase efficiency and extend range.

SUMMARY OF THE INVENTION

An impeller is improved by providing partial height blades between full blades.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 shows in cross section a centrifugal compressor impeller incorporating the improvement of the present invention.

FIGURES 2-4 show in cross section, a portion of a centrifugal compressor impeller incorporating alternate expressions of the present invention.

FIGURE 5 shows a front plan view of a centrifugal compressor impeller, illustrating suitable locations for the partial height blades of the present invention.

FIGURES 6-8 shows a cross section of a centrifugal compressor impeller, wherein partial height blades of different shapes and locations are illustrated.

FIGURE 9 shows in front plan view a shrouded impeller incorporating partial height blades on both the hub and shroud surfaces.

FIGURE 10 shows in cross section, a shrouded impeller incorporating partial height blades.

FIGURES 11 a, b and c show in cross section variants of the present invention, wherein the leading edge or trailing edge of the partial height blade, or both, extend beyond the full height blades.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIGURE 1, an impeller 10 according to the improvements of the present invention generally includes a hub 11 defined by an intake 12 and an exit 13. The hub has an outer surface 14. A plurality of full height blades 15 are located about the outer surface 14. As the hub spins about a shaft 16 which turns about a central axis 17, fluid enters the intake 12, passes along the flow path between adjacent blades 15 and is ejected under pressure from the exit 13. The inventive aspect of the device shown in FIGURE 1 is the inclusion of partial height blades 18 between adjacent full height blades. The height of a blade is measured with reference to an imaginary line tangent to the outer surface 14. For the present purposes, a partial height blade is one which is between 5 and 85 percent the height of an adjacent full height blade at any point. Partial height blades increase the efficiency and range of the compressor to which the improved impeller is affixed. The partial height blade 18 includes a leading edge 19 and a trailing edge 20. In the example of FIGURE 1, it can be seen that the leading edge is both tapered and located somewhat away from the intake 12 and is thus said to be intermediate the intake and the exit. The trailing edge 20 terminates at the exit 13. It should be understood that a variety of leading edge tapers and varying degrees of recession of the leading edge away from the intake will all produce beneficial results.

FIGURE 2 shows that the leading edge 19 can terminate at the intake 12, just as the trailing edge 20 terminates at the exit 13. A further variation is

depicted in FIGURE 3 where it is shown that the trailing edge can be receded from the exit so that it is intermediate the exit 13 and the intake 12. In FIGURE 4, both leading edge 19 and trailing edge 20 are receded and thus both are intermediately located. In FIGURE 11a, the partial height blade 47 has a leading edge 41 which is seen as extending beyond the inducer leading edge 42. In FIGURE 11b, the partial height trailing edge 43 is shown as extending beyond the trailing edge 44 of the full height blade 48. In FIGURE 11c, the partial height blade is depicted as extending beyond the inducer or leading edge 45 of the full height blade 49 and the trailing edge 46 of the full height blade. It will be appreciated that a variety of leading edge and trailing edge variations may be practiced, all having beneficial results over impellers with only full height blades.

As seen in FIGURE 5, full height blades are closer together at the intake 12 than at the exit 13. However, the flow path 21 between adjacent blades is characterized by a centerline which runs along the outer surface 14 and which is equidistant from either adjacent blade 15 at any point. In the preferred embodiment, the partial height blade follows the flow path centerline. However, the present invention is not so limited as circumferential displacement of partial height blades 22, 23 from the centerline in either direction will produce advantages in impeller performance. Moreover, more than one partial height blade may be interposed between each adjacent pair of full height blades. In such designs, the partial height blades may be either of the same height or of different heights. This is true

for all the configurations to follow as well as those previously mentioned.

The exact shape or cross section of the partial height blade is also variable. FIGURE 6 shows blades 24, 25 inclined with respect to the radius of the impeller. Inclined blades would take the place of a radially upright blade 18. FIGURE 7 shows a J-shaped blade 26 and alternate J-shaped blade locations 27 and 28. Note that the curved tip 29 of the J-shaped blade points away from the direction of rotation 30 of the hub.

Pyramidal partial height blades are contemplated as well. FIGURE 8 shows a centrally located pyramidal partial height blade 31 and alternate off-center located blades 32 and 33. A blade is considered pyramidal when the base of the blade 34, at the point of attachment, is wider than the tip portion 35. Thus, it can be appreciated that the partial height blades may take a form considerably different from that of the adjacent full height blades. It is to be understood that more than one partial height blade may be interposed between adjacent full height blade pairs, that such partial height blades may have a different cross section than the full height blades and that they need not be centered between full height blades.

Finally, it should be mentioned that the aforestated improvements pertaining to partial height blades are equally applicable to shrouded impellers. FIGURE 9 shows a shrouded impeller 36, generally characterized by a shroud 37 which encloses the flow paths.

In the shrouded impeller situation, partial height blades may be located opposite one another along the flow path. Thus, one partial height blade 38 is located on the hub, while another partial height blade 39 is located on the shroud. Note that the hub and shroud blades 38, 39 need not be located opposite one another. They may be displaced from one another circumferentially. In the case of the shrouded impeller, partial height blades should be limited in their combined height to between 5 and 85 percent of the full blade height. Any of the aforementioned partial height blade shapes are adaptable to the shrouded impeller application. As seen in FIGURE 10, a partial height blade of any variety 40 can be located on the hub only, thus eliminating the shroud blade 39. Similarly, a partial height blade of any variety may be located on the shroud only, thus eliminating the hub blade.

While the present invention has been described in conjunction with specific equipment, it should be noted that the principles of practicing the invention are widely applicable to a variety of full height and partial height blade configurations as well as a variety of rotor designs for turbine and compressor configurations. Partial height blades are, for example, fully utilizable in radial or mixed flow centrifugal compressors, axial compressors, radial turbines and axial turbines. Thus, the scope of the invention should not be limited by the examples given, but rather, interpreted by the accompanying claims.

WHAT IS CLAIMED IS:

1. In an impeller having a central axis, an intake, an exit, an outer surface and a plurality of full height blades disposed about the outer surface, where adjacent blades define a flow path having a centerline, the improvement comprising:

partial height blades located between the full height blades.

2. The improved impeller of Claim 1 wherein the partial height blade is located along the centerline and extends from the outer surface to a height of from 5-85 percent of the height of the full height blade.

3. The improved impeller of Claim 2 wherein the partial height blade further comprises a leading edge and a trailing edge, the leading edge terminating at the intake of the impeller.

4. The improved impeller of Claim 2 wherein the leading edge is located intermediate the intake end and the exit.

5. The improved impeller of Claim 3 or 4 wherein the trailing edge is located intermediate the intake and the exit.

6. The improved impeller of Claim 3 or 4 wherein the trailing edge terminates at the exit of the impeller.

7. The improved impeller of Claim 1 wherein the partial height blade is circumferentially displaced from the centerline and extends from the outer surface to a height of from 5-85 percent of the height of the full height blade.

8. The improved impeller of Claim 7 wherein the partial height blade further comprises a leading edge and a trailing edge, the leading edge terminating at the intake of the impeller.

9. The improved impeller of Claim 7 wherein the leading edge is located intermediate the intake end and the exit.

10. The improved impeller of Claim 8 or 9 wherein the trailing edge is located intermediate the intake and the exit.

11. The improved impeller of Claim 8 or 9 wherein the trailing edge terminates at the exit of the impeller.

12. In an impeller having a central axis, an intake region, an exit, an outer surface and a plurality of full height blades disposed about the outer surface, where adjacent blades define a flow path having a centerline, the improvement comprising:

a plurality of partial height blades between adjacent full height blades.

13. The improved impeller of Claim 12, wherein the partial height blades are of equal height.

14. In a turbomachine having a central axis, a rotor intake, a rotor exit, a rotor outer surface and a plurality of full height blades disposed about an outer surface of the rotor, where adjacent blades define a flow path having a centerline, the improvement comprising:

partial height blades located between the full height blades.

15. In a turbomachine rotor having a central axis, an intake region, an exit, an outer surface and a plurality of full height blades disposed about the outer surface, where adjacent blades define a flow path having a centerline, the improvement comprising:

partial height blades located between the full height blades; and

full height blades having leading edges, the partial height blades terminating at one end axially beyond the leading edges of the full height blades.

16. The improved turbomachine of Claim 15, wherein:

the full height blades further comprise trailing edges, the partial height blades terminating, at the other end, beyond the trailing edges of the full height blades.

17. In a turbomachine rotor having a central axis, an intake, an exit, an outer surface and a plurality of full height blades disposed about the outer surface, where adjacent blades define a flow path having a centerline, the improvement comprising:

partial height blades located between the full height blades; and

full height blades having trailing edges, the partial height blades terminating beyond the trailing edges of the full height blades.

18. In a turbomachine having a central axis, an intake, an exit, a rotor outer surface and a plurality of full height blades disposed about the outer surface, where adjacent blades define a flow path having a centerline, the improvement comprising:

a plurality of partial height blades located between adjacent full height blades.

19. The improved turbomachine of Claim 18, wherein at least one partial height blade between adjacent full height blades is of a different height than the other partial height blades therebetween.

20. In a turbomachine rotor having a central axis, an intake, an exit, an outer surface and a plurality of full height blades disposed about the outer surface, where adjacent blades define flow paths having centerlines, the improvement comprising:

partial height blades located between the full height blades;

wherein the partial height blades are circumferentially disposed from the centerlines of the flow paths.

21. In an impeller having a central axis, an intake region, an exit, a shroud, an outer surface and a plurality of full height blades disposed between the outer surface and the shroud, where adjacent blades define a flow path having a centerline, the improvement comprising:

one or more partial height blades between adjacent full height blades.

22. The improved impeller of Claim 21, wherein all the partial height blades are of equal height.

23. The improved impeller of Claim 21, wherein the partial height blades are located on both the hub and the shroud.

24. The improved impeller of Claim 21, wherein the partial height blades on the hub are circumferentially displaced from the partial height blades on the shroud.

25. The improved impeller of Claim 21, wherein partial height blades are provided on the hub and have a different cross-section than partial height blades provided on the shroud.

26. The improved impeller of Claim 21, wherein partial height blades are provided only on the hub.

27. The improved impeller of Claim 21, wherein partial height blades are provided only on the shroud.

FIG. 1

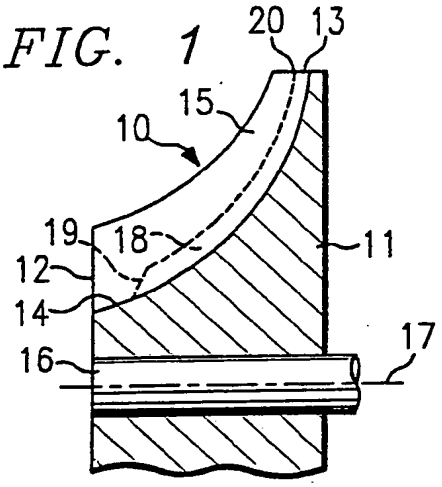


FIG. 2

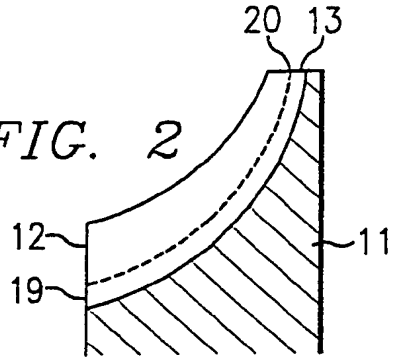


FIG. 3

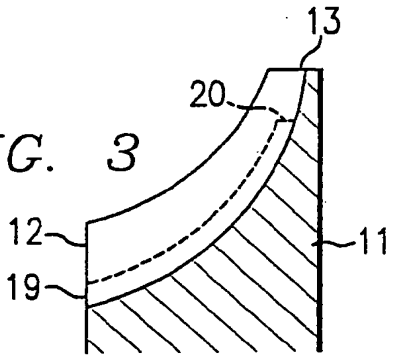


FIG. 4

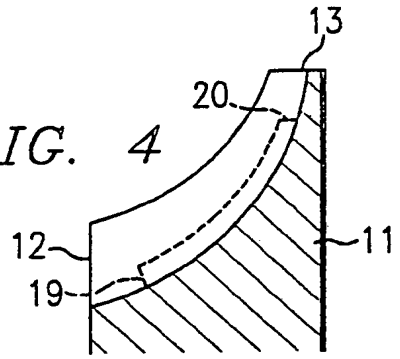


FIG. 5

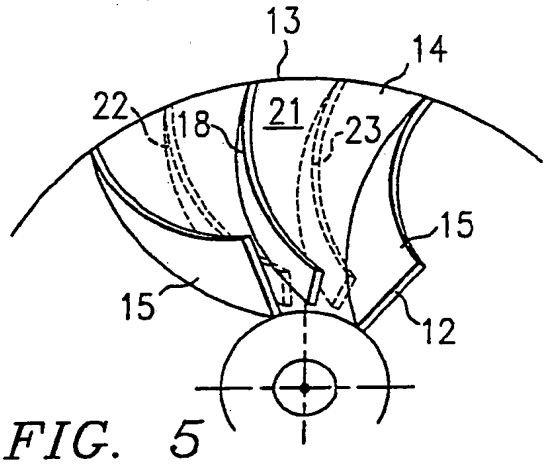


FIG. 6

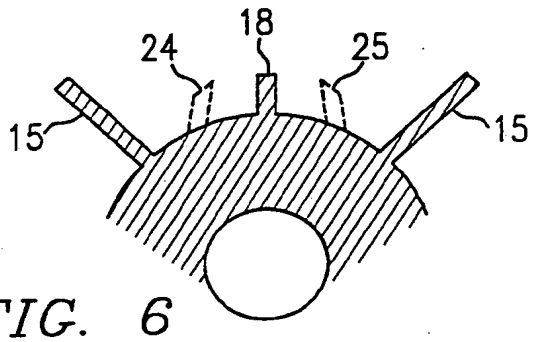
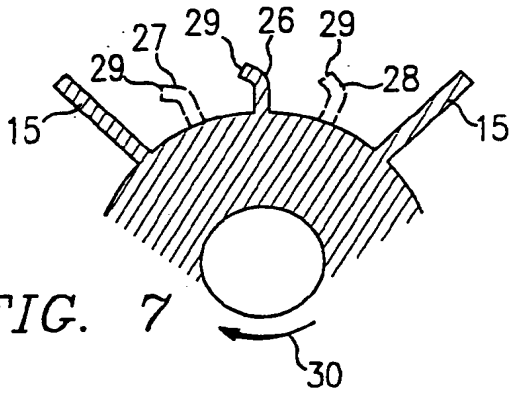


FIG. 7



SUBSTITUTE SHEET

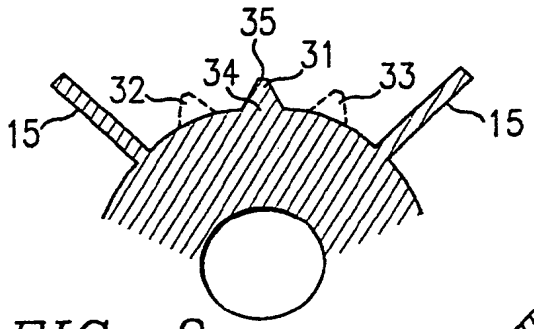


FIG. 8

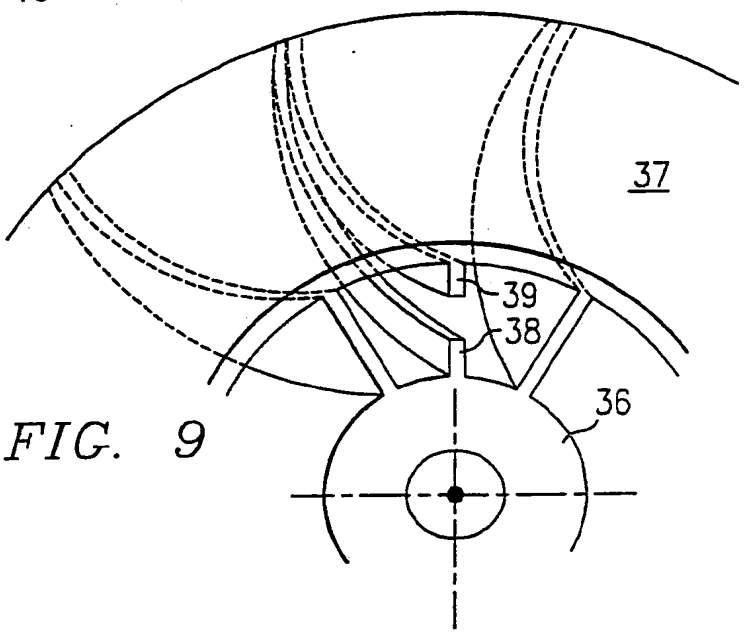


FIG. 9

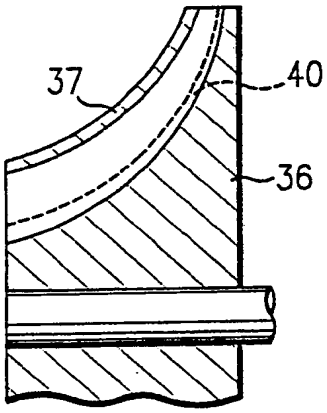


FIG. 10

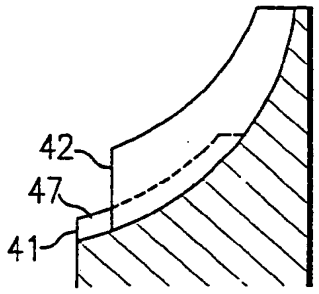


FIG. 11a

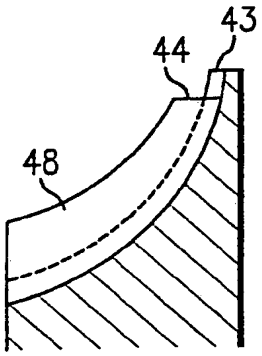


FIG. 11b

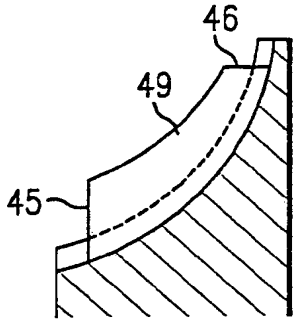


FIG. 11c

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/03437

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4) F04D 17/10
US CL. 416/183

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	416/183,175,203

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 2,648,493 (STALKER) 11 August 1953	1-27
Y	US, A, 2,920,864 (LEE) 12 January 1960	1-27
Y	US, A, 3,481,531 (MacARTHUR et al) 2 December 1969	1-27
Y	US, A, 3,904,308 (RIBAUD) 9 September 1975	1-27
Y	US, A, 4,093,401 (GRAVELLE) 6 June 1978	1-27
Y	US, A, 4,195,473 (ASPINWALL) 1 April 1980	1-27
Y	US, A, 4,502,837 (BLAIR et al) 5 March 1985	1-27
Y	GB, A, 2,053,368 (PRETZSCHEL et al) 4 February 1981	1-27
Y	JP, A, 69,211 (MATSUO) 19 April 1985	1-27
Y	SU, A, 1,059,217 (DAVYDOV) 07 Dec. 1983	1-27

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
17 October 1989	14 NOV 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Everette A. Powell, Jr.

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